Effects of freshwater inflows on the oyster population in the Caloosahatchee Estuary

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Outline

I. Background

II. Field observations (populations along a salinity gradient)
   a. Salinity and freshwater input
   b. Recruitment of oyster spat
   c. Gametogenesis in adult oysters
   d. Density of living oysters

III. Laboratory analysis
   a. Early life stage exposure to changes in salinity and temperature
      i. Gametes
      ii. Embryos
      iii. Larvae
   b. Exposure of adult oysters
      a. Continuous and pulse exposure

IV. Conclusions

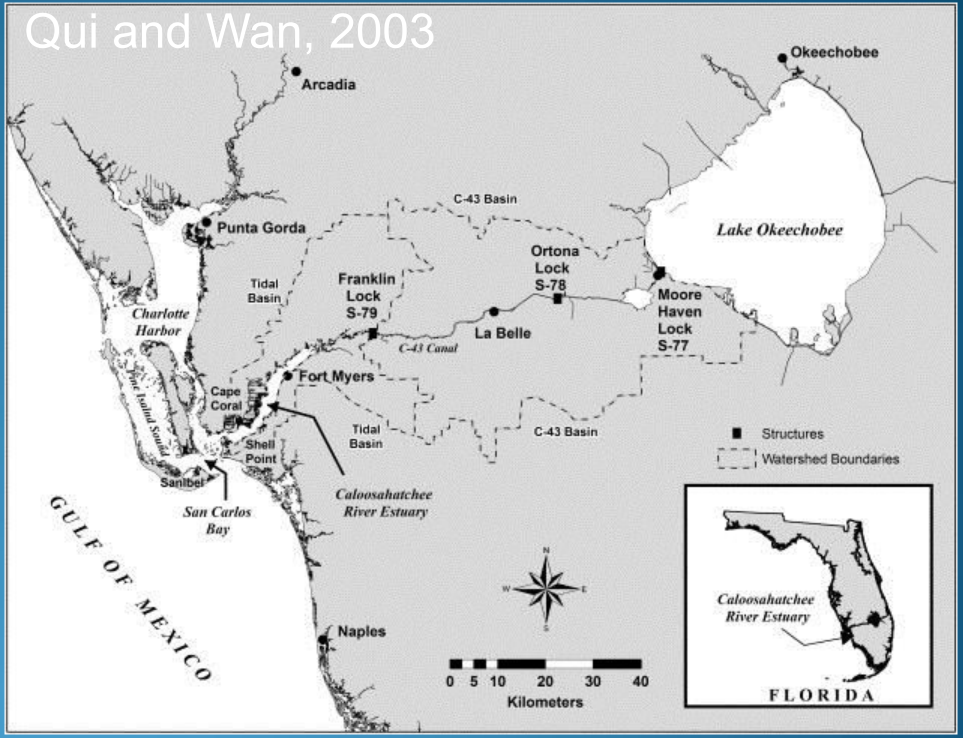
Why study oyster reefs?

Oysters are ecosystem engineers

- Complex 3-D structure = essential habitat for commercially and ecologically important species
- Filtration of the water column = improved water quality
- Act as natural break walls = shoreline protection
- Aid in sedimentation
- Provide substrate for mangroves

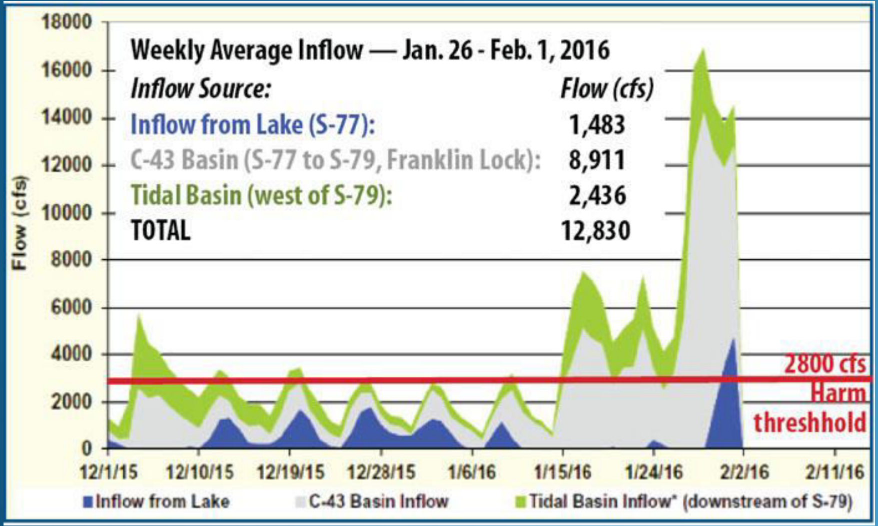
Background

- The Caloosahatchee watershed has been dramatically altered by human activities
- Fresh water flow is managed by 3 locks and damns along the river



Background

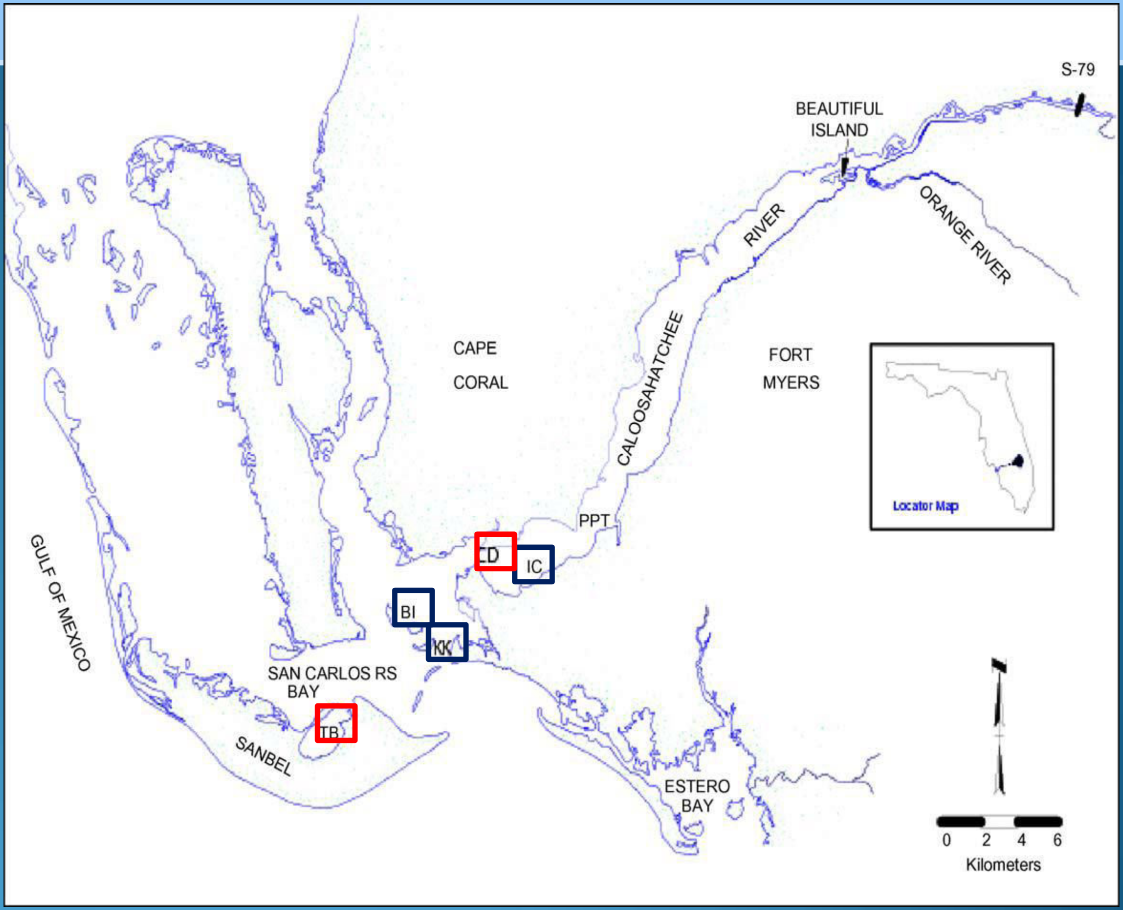
2016 freshwater releases



Sites

Sites were chosen along a salinity gradient within the Caloosahatchee Estuary

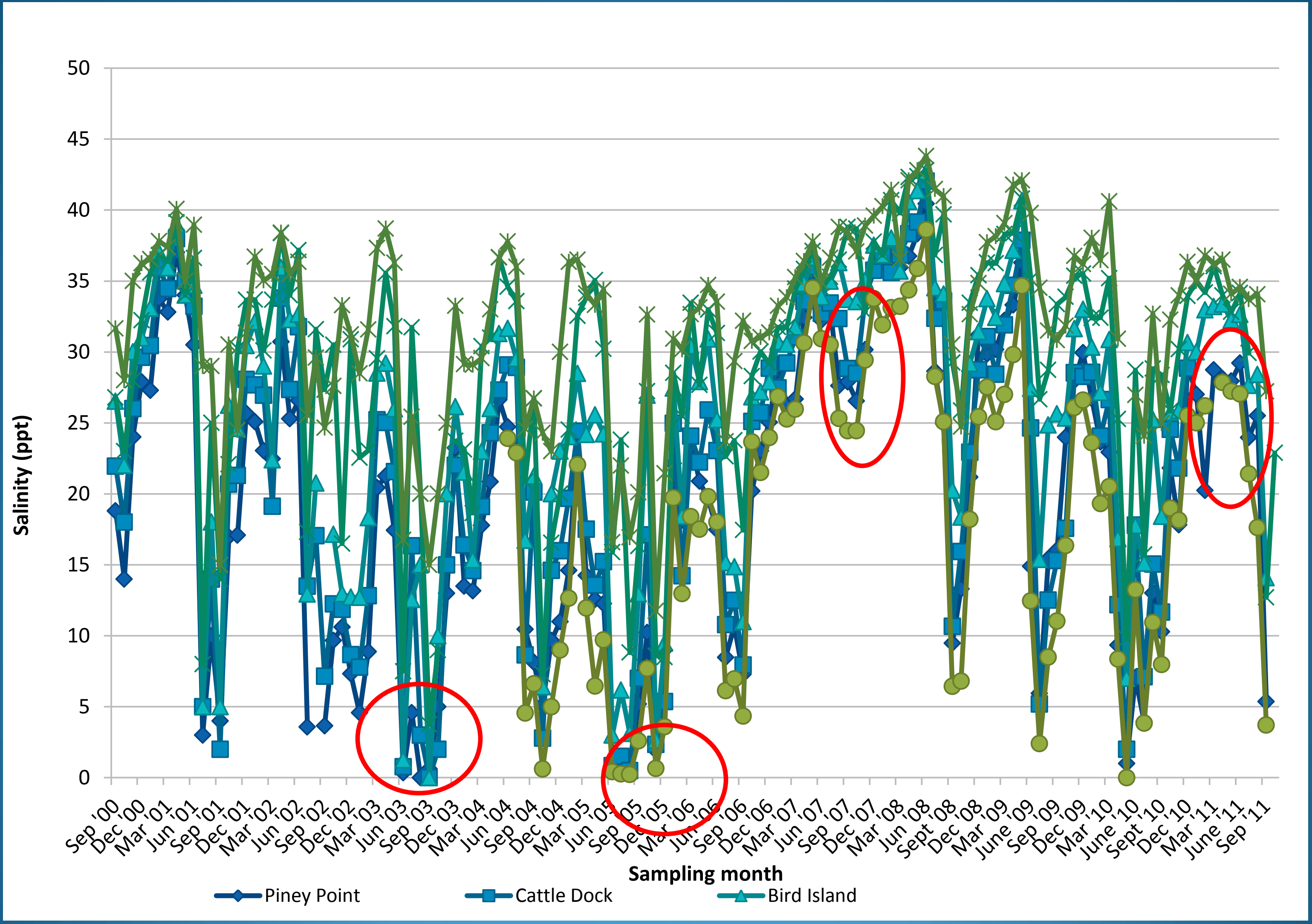
Site 1: Iona Cove (IC)
Site 2: Cattle Dock (CD)
Site 3: Bird Island (BI)
Site 4: Kitchel Key (KK)
Site 5: Tarpon Bay (TB)



Parameters measured

- Temperature, salinity, D. O.
- Flow (CFS; SFWMD)
- *Perkinsus marinus* intensity and prevalence
- Gonadal Index
- Spat Recruitment
- Survival (including predation)
- Living density
- Controlled lab experiments

Salinity


Salinity (ppt)
50
45
40
35
30
25
20
15
10
5
0
Sep '00
Dec '00
Mar '01
Jun '01
Sep '01
Dec '01
Mar '02
Jun '02
Sep '02
Dec '02
Mar '03
Jun '03
Sep '03
Dec '03
Mar '04
Jun '04
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Jun '08
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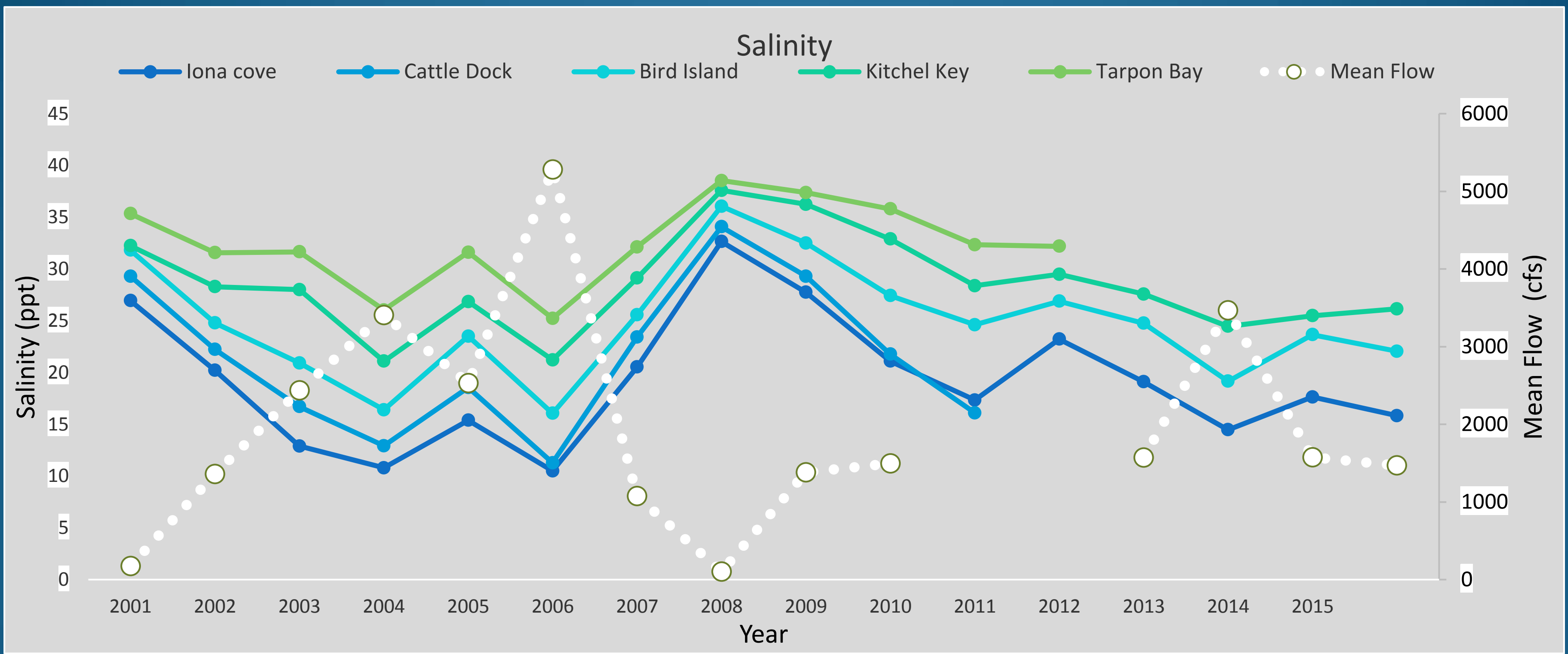
Mar '09
June '09
Sep '09
Dec '09
Mar '10
June '10
Sept '10
Dec '10
Mar '11
June '11
Sep '11
Sampling month
Piney Point
Cattle Dock
Bird Island

Salinity vs. flow

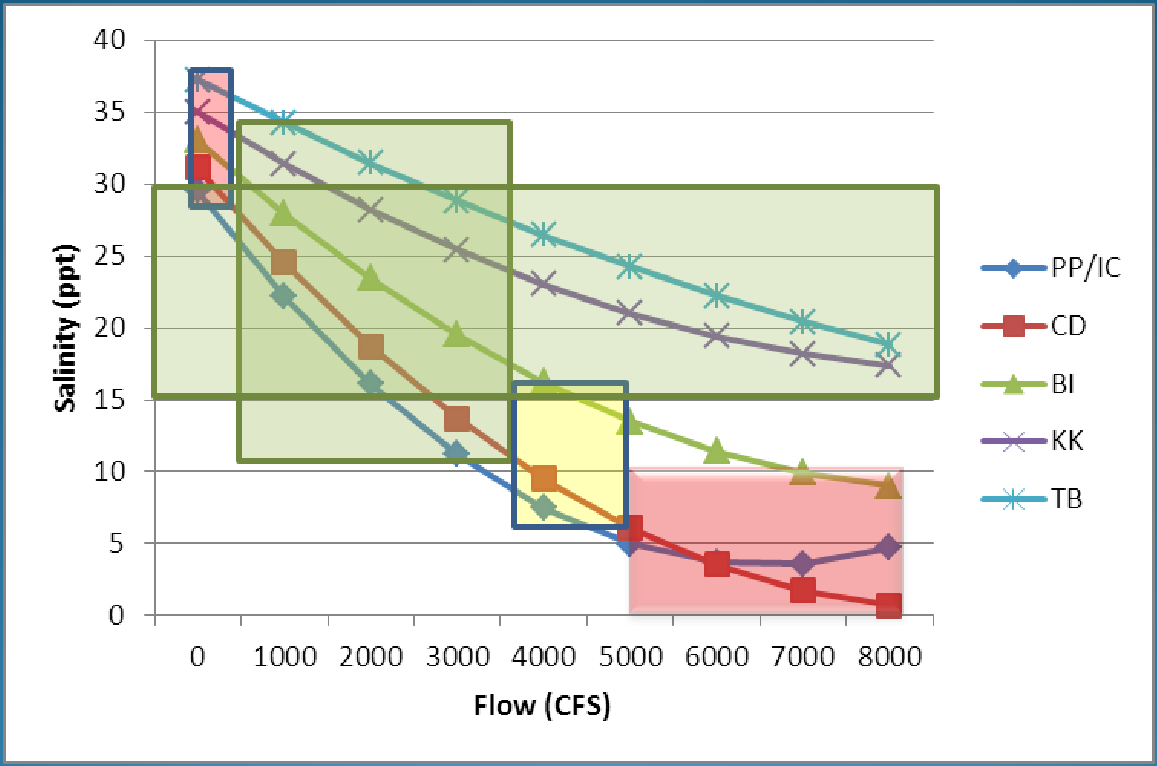


Salinity is correlated with freshwater flow at all sites

Classification of years

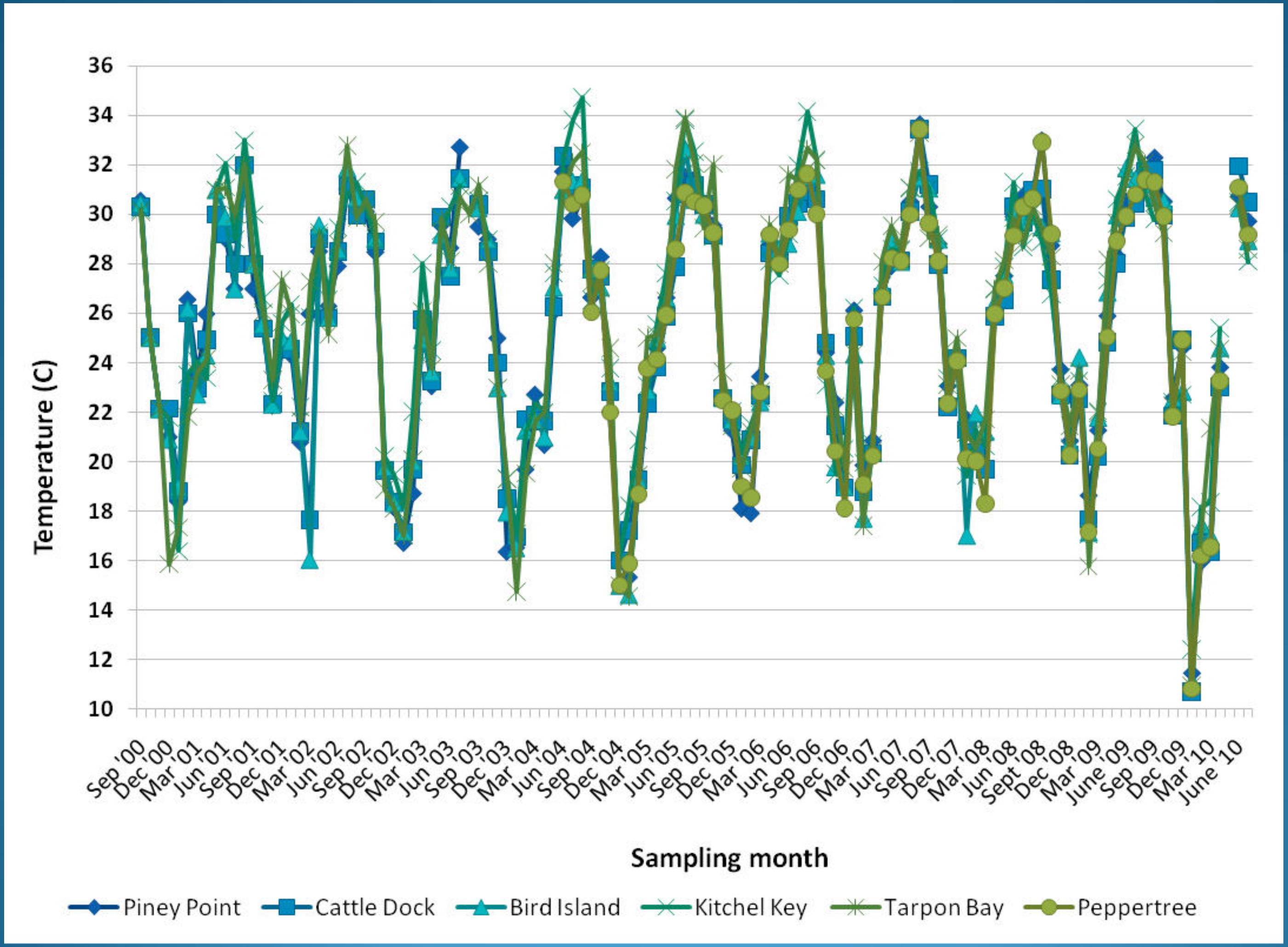
- Water years are classified as either wet, dry or normal based on salinities at Cape Coral Bridge in the Caloosahatchee Estuary.
- Values of <16, ≥ 16 to ≤ 28, and > 28 provided criteria for classifying water years as wet, normal, or dry years respectively.
- Water years 2003, 2004, 2005 and 2006, 2013, 2014, 2015 were wet, years 2002, 2007, 2010, 2011 and 2013 were normal and years 2008, 2009 and 2012 were dry years

Salinity - Flow

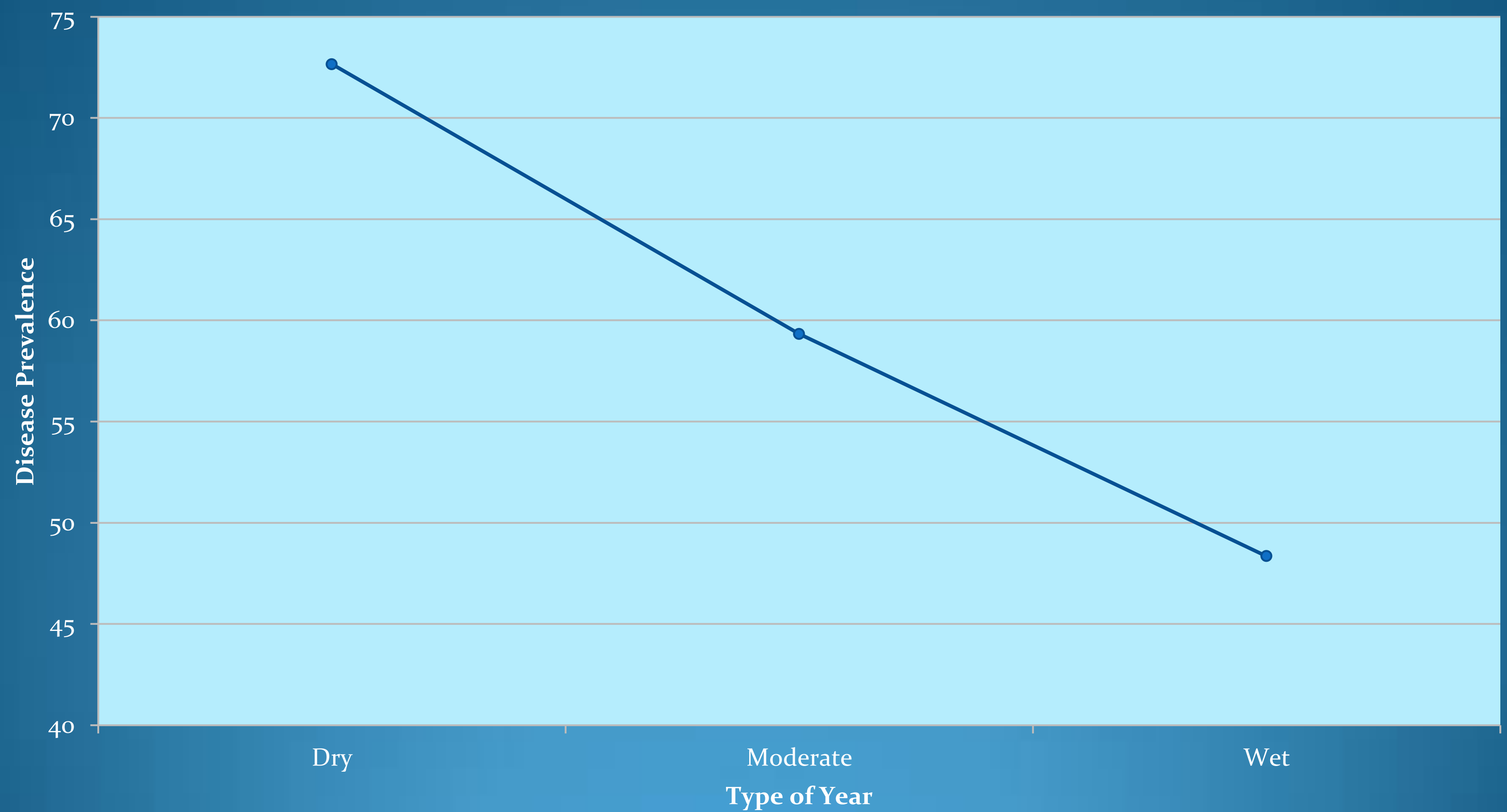


Station	Relationship	R^2
Iona Cove	Y=5e-07X2-0.0078X+29.719	R^2=0.73
Cattle Dock	Y=4e-07X2-0.007X+31.234	R^2=0.68
Bird Island	Y=3e-07X2-0.0053X+33.241	R^2=0.64
Kitchel Key	Y=1e-07X2-0.0036X+32.222	R^2=0.58
Tarpon Bay	Y=1e-07X2-0.0032X+37.351	R^2=0.61

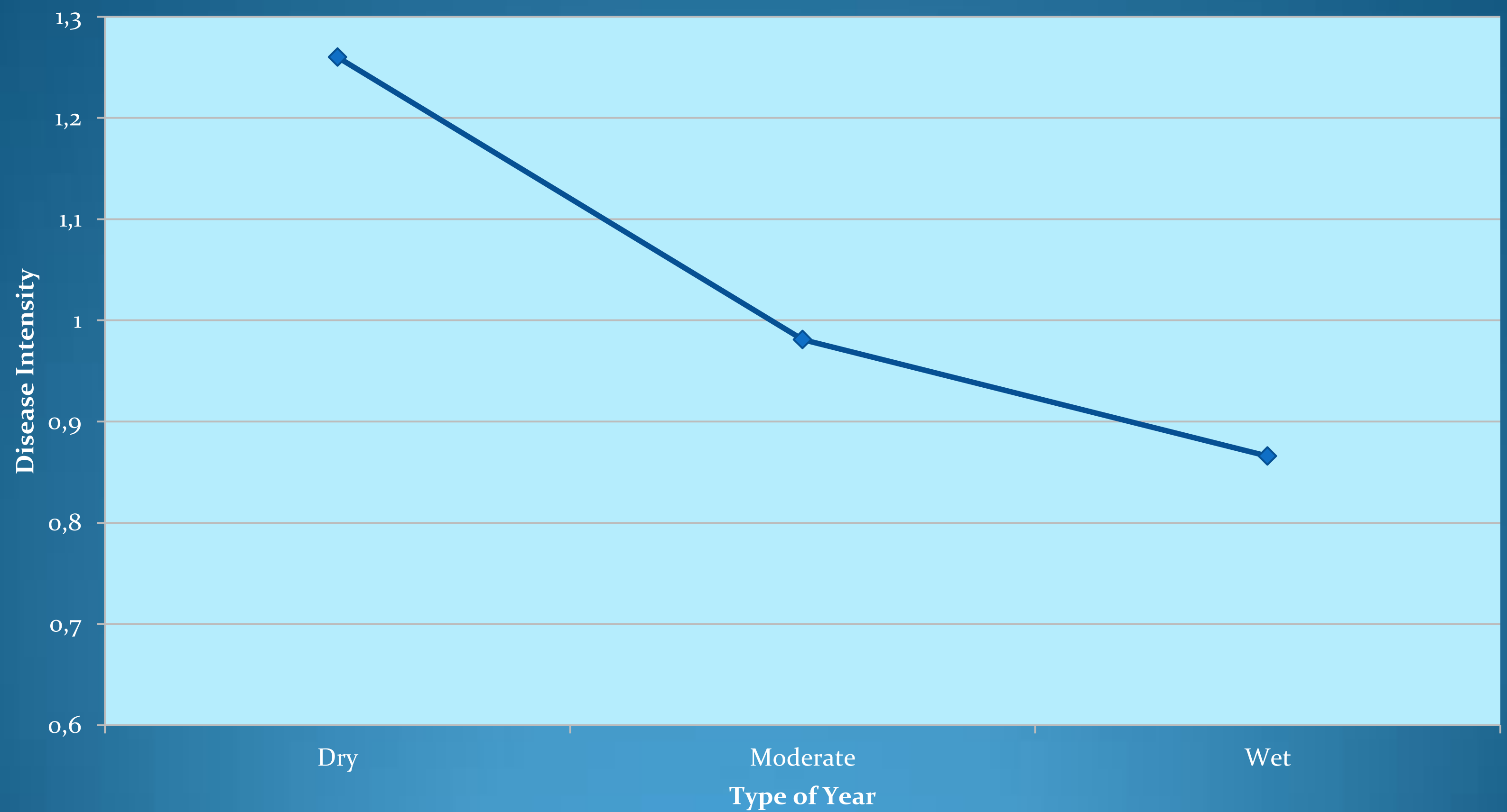
Temperature



Disease Prevalence

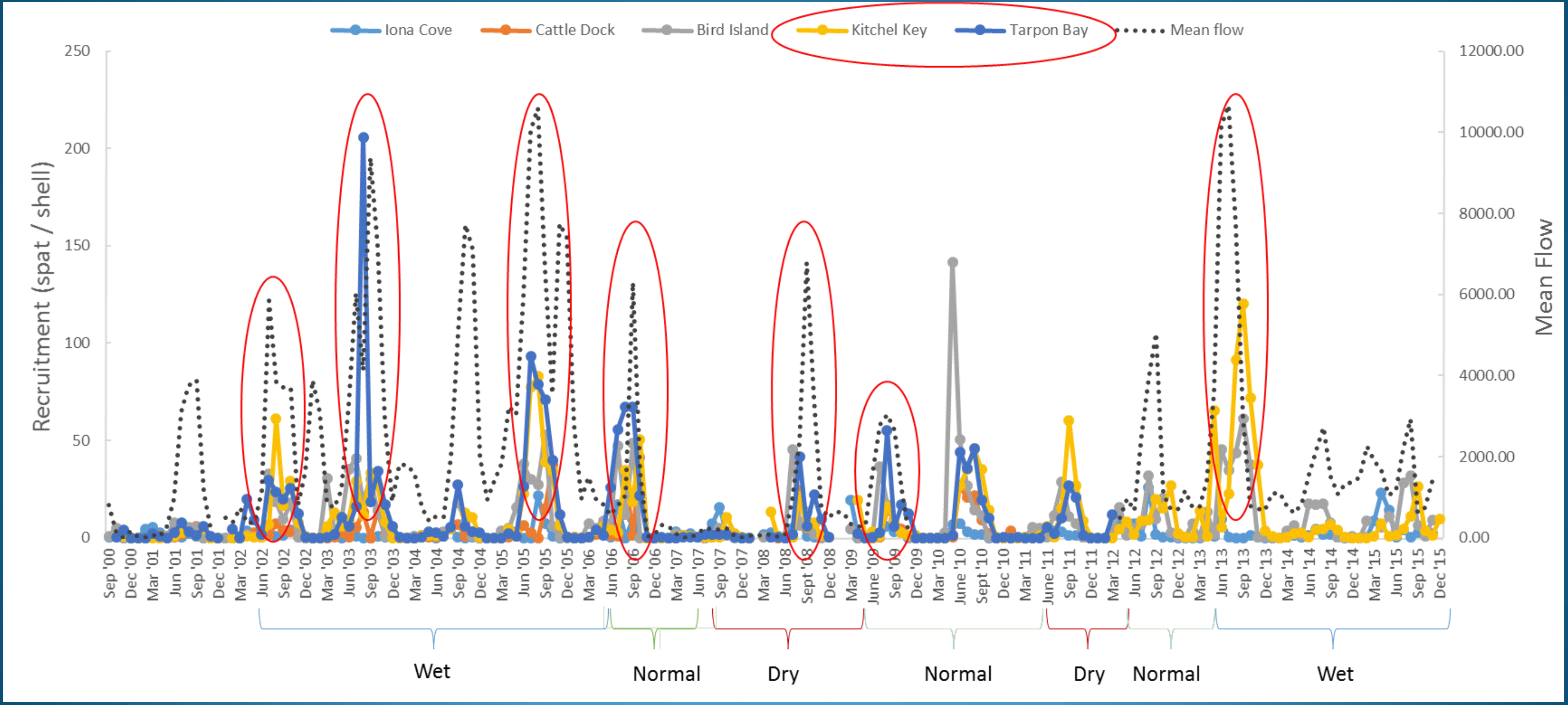


Disease Intensity



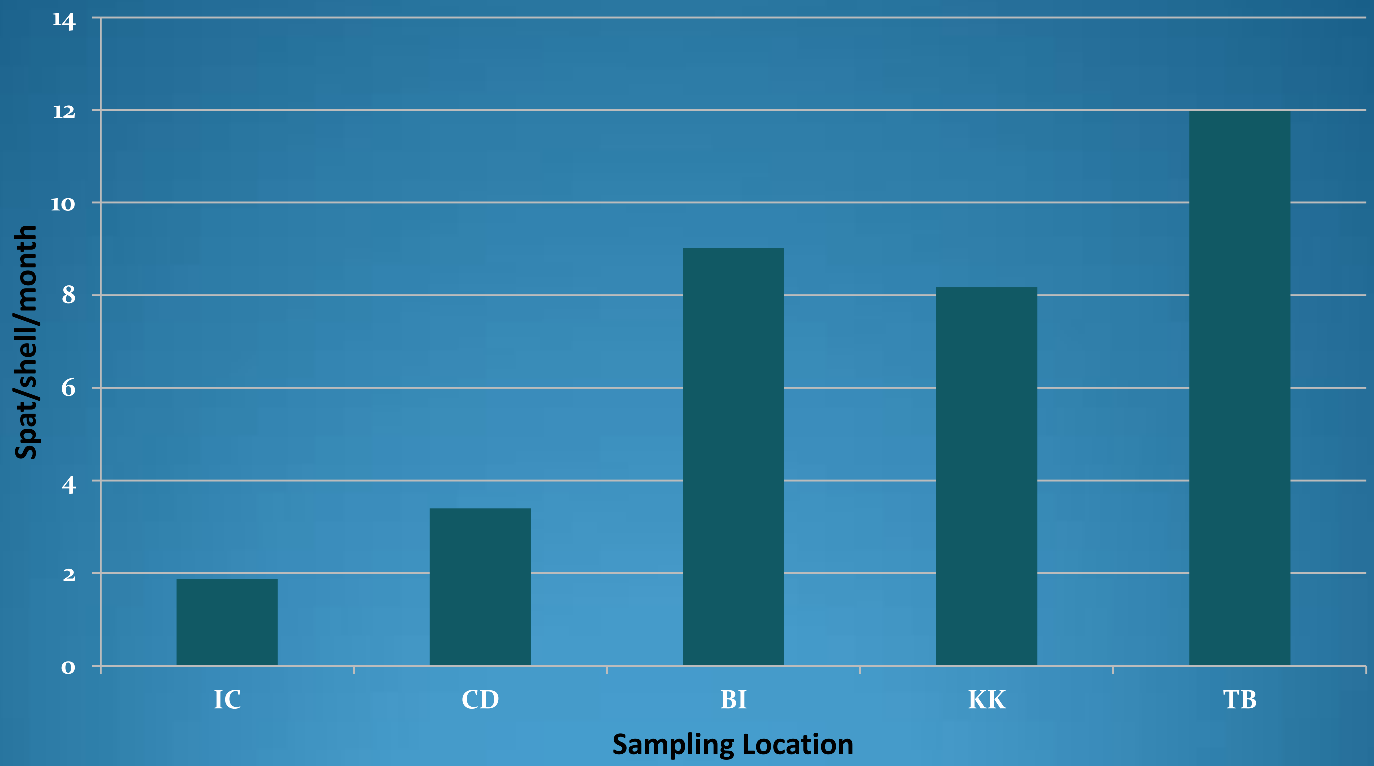
Recruitment in relation to freshwater input

Peak in recruitment at downstream sites when the freshwater release is high

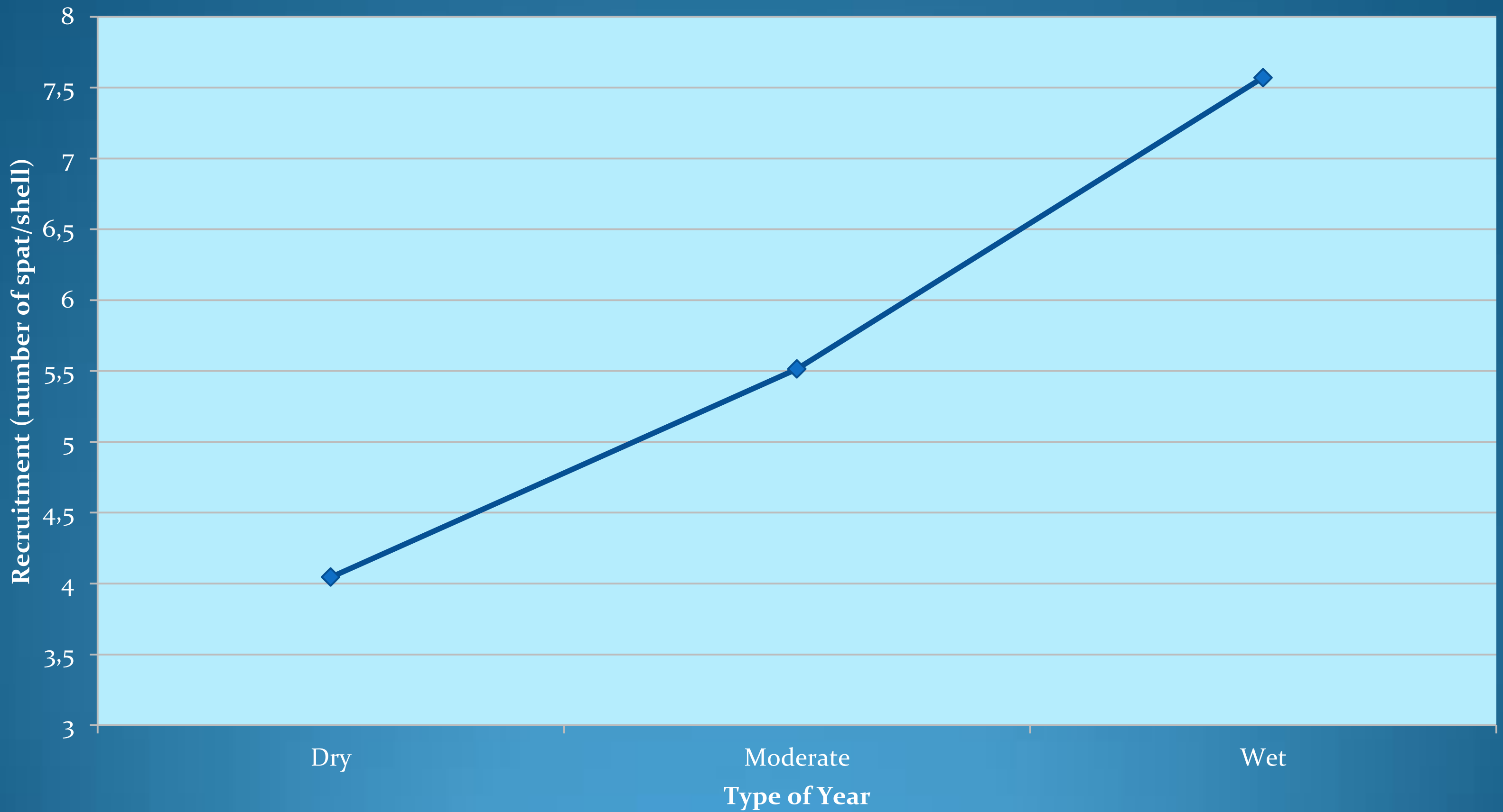


Spat recruitment

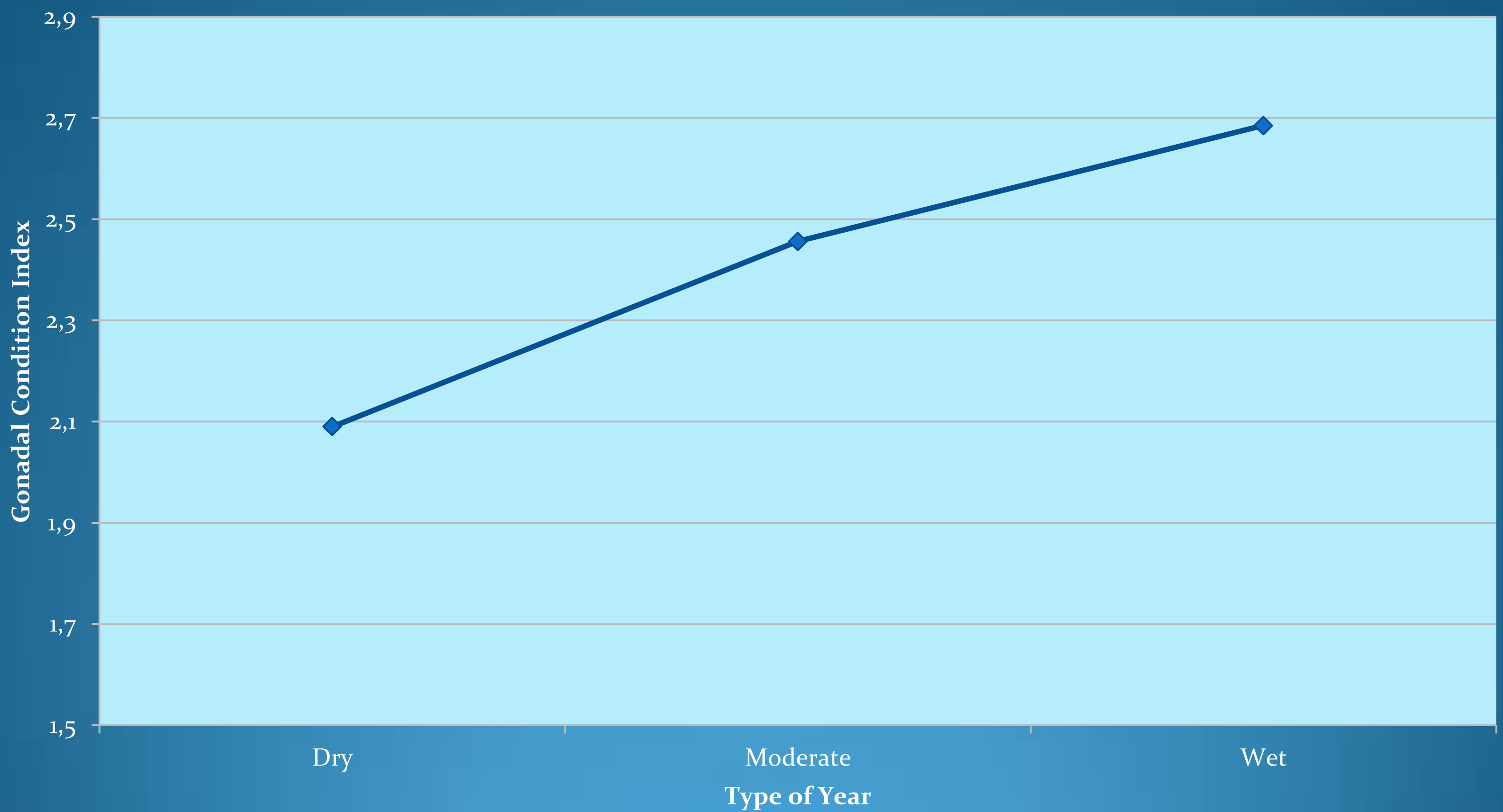
Spat Recruitment



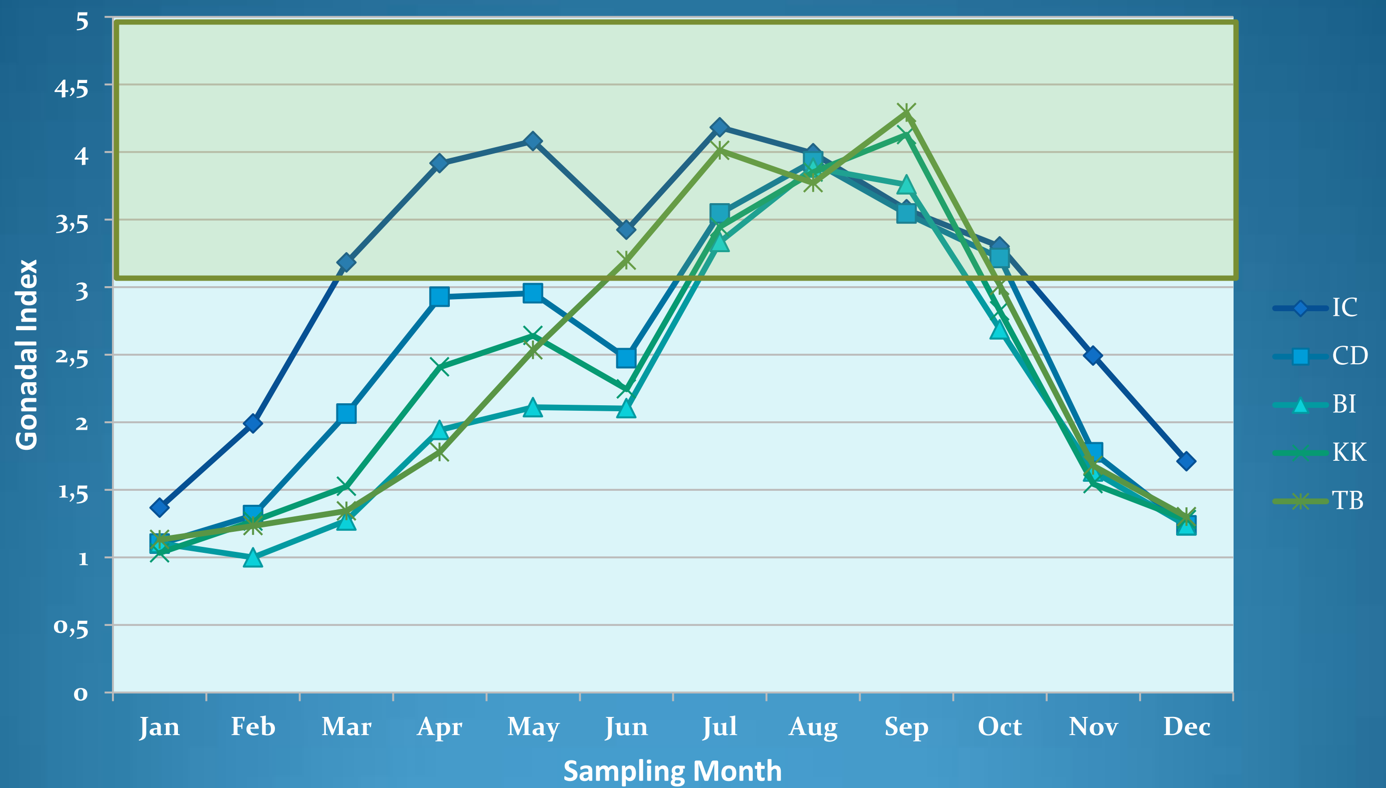
Spat Recruitment



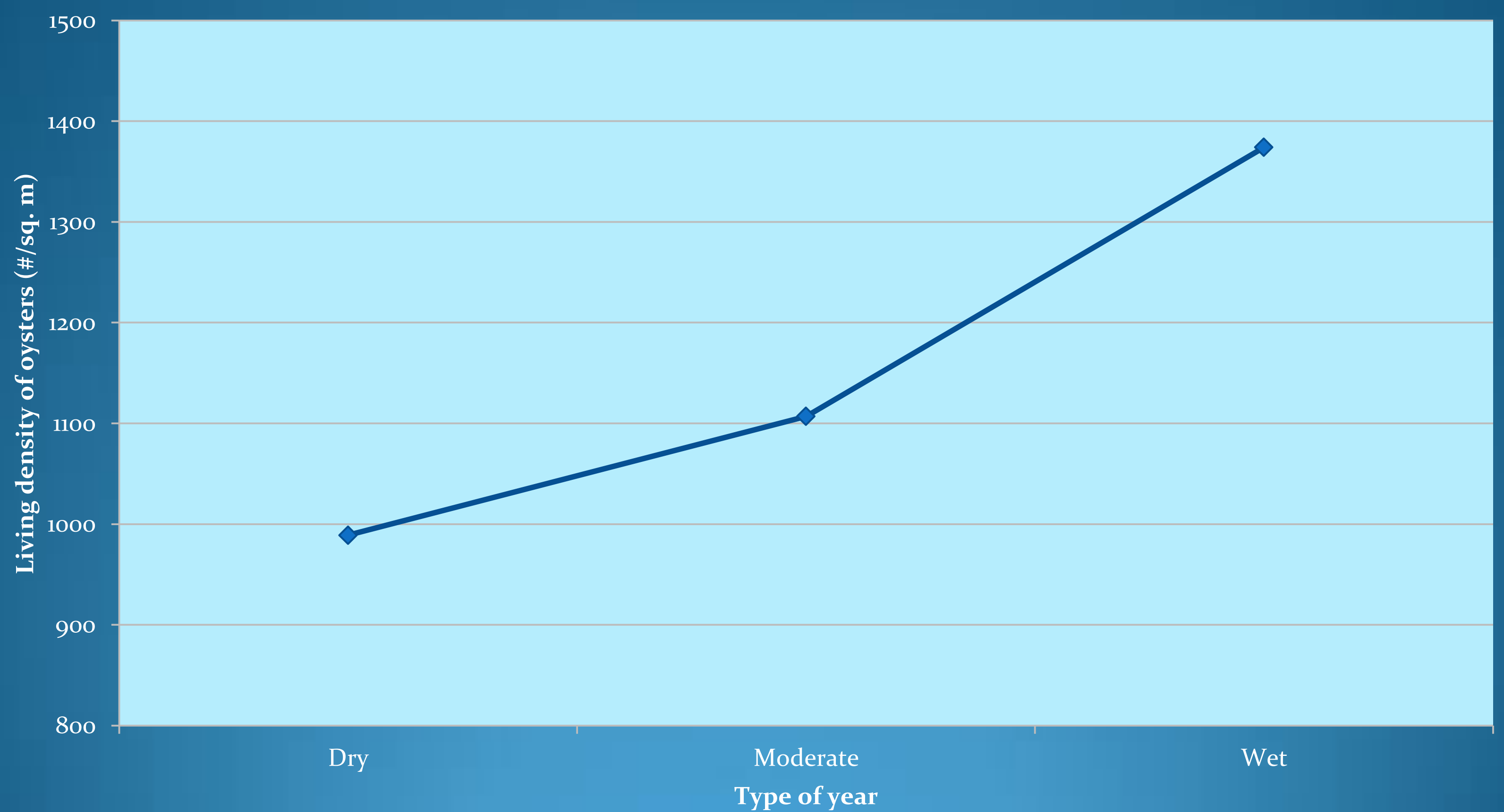
Gonadal Condition



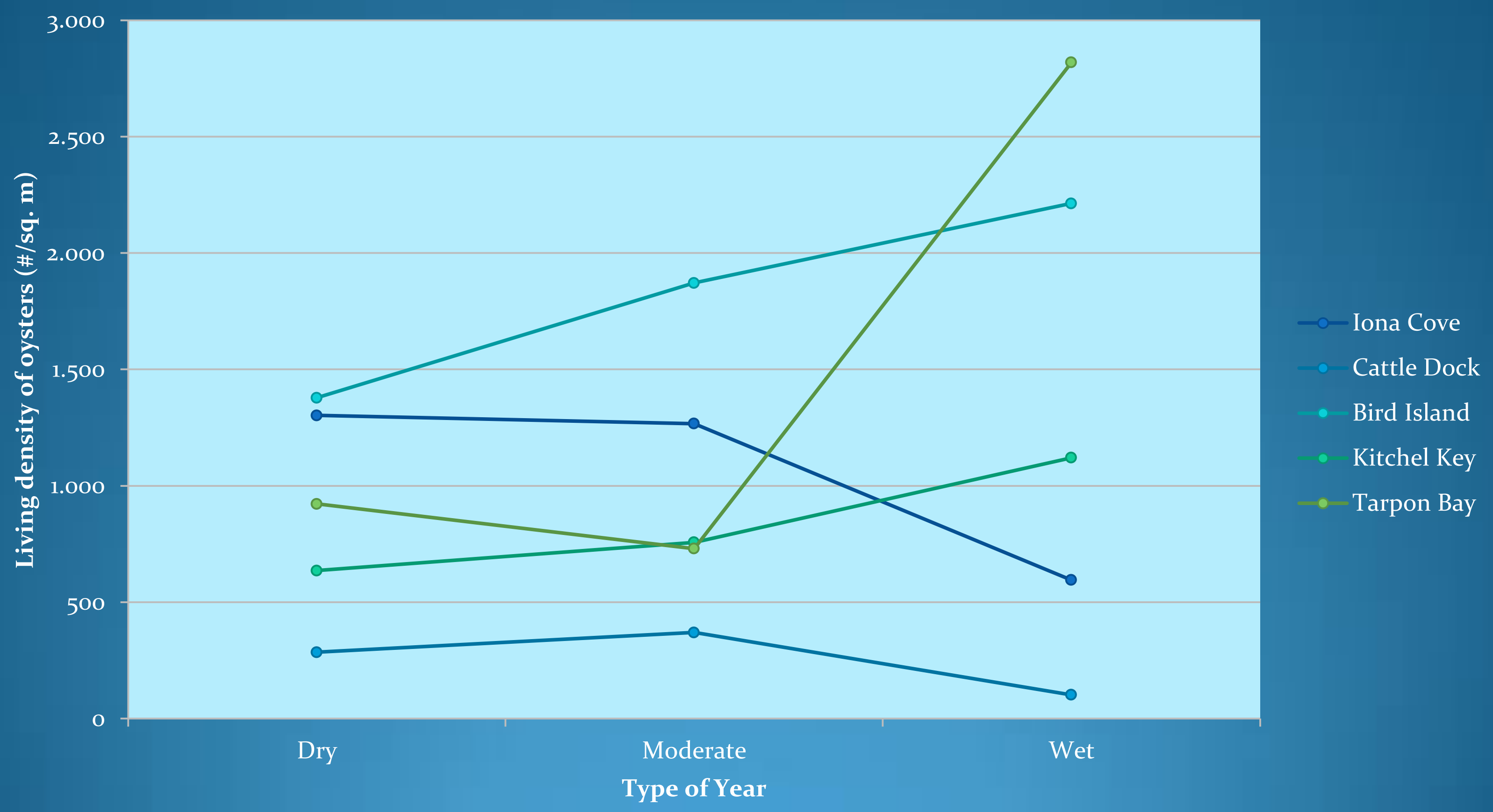
Gonadal Index (reproduction)



Living Density



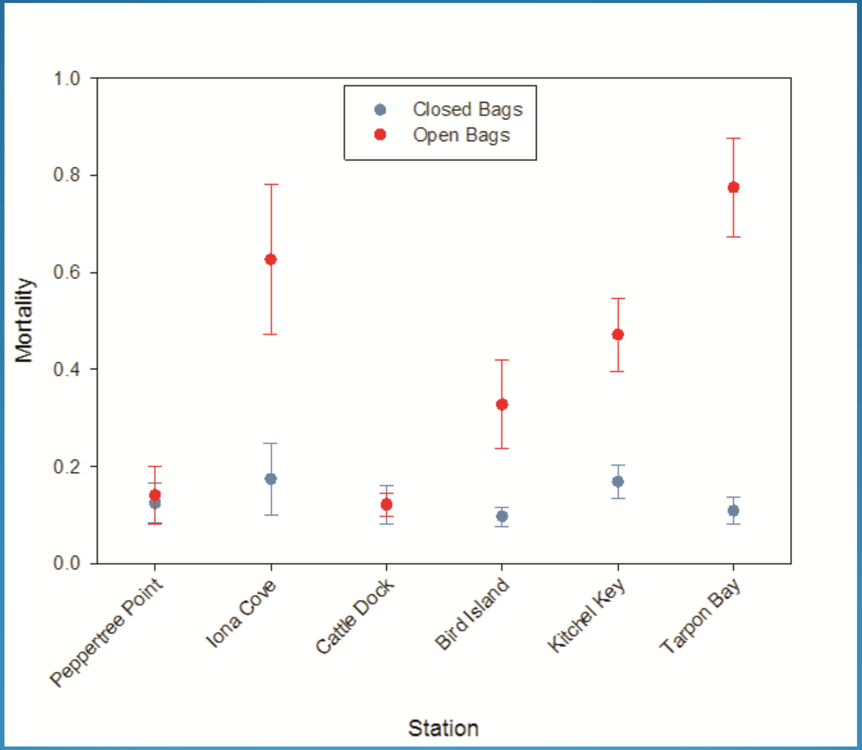
Living Density



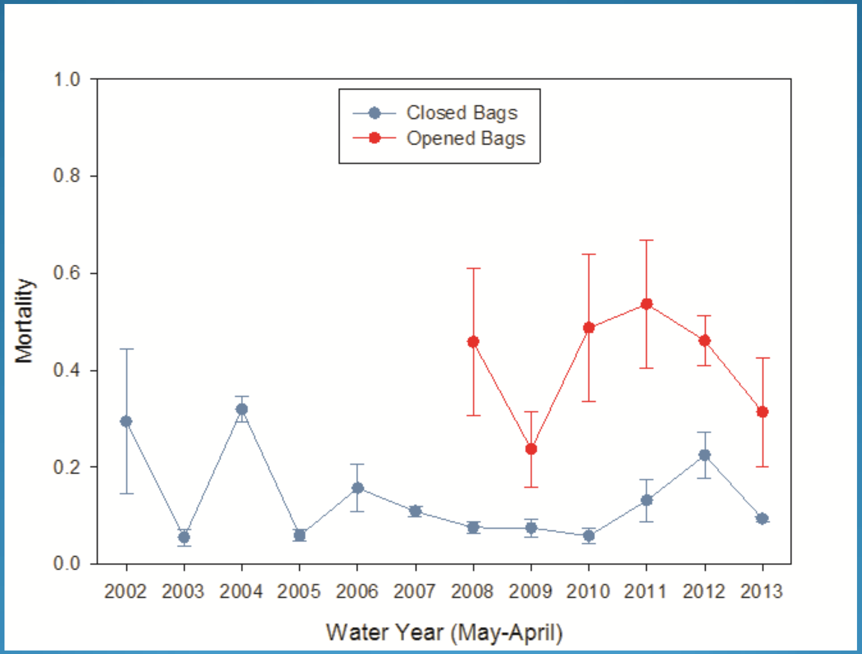
Effect of Salinity

Predation and survival

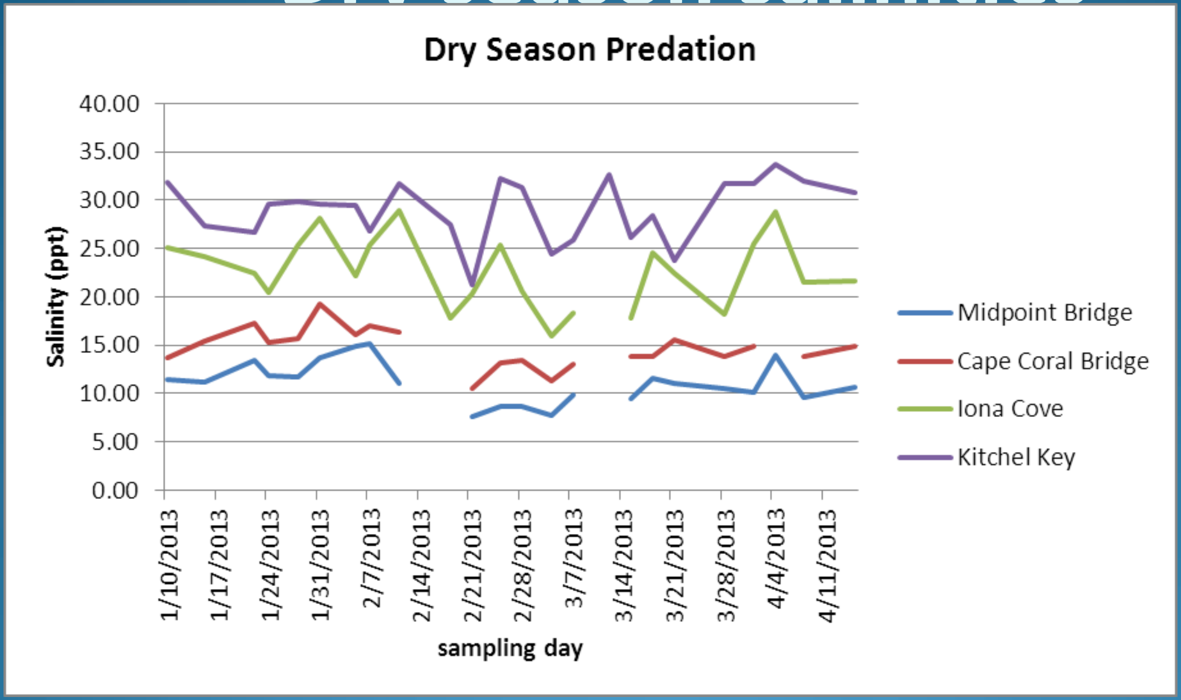
Predation Pressure



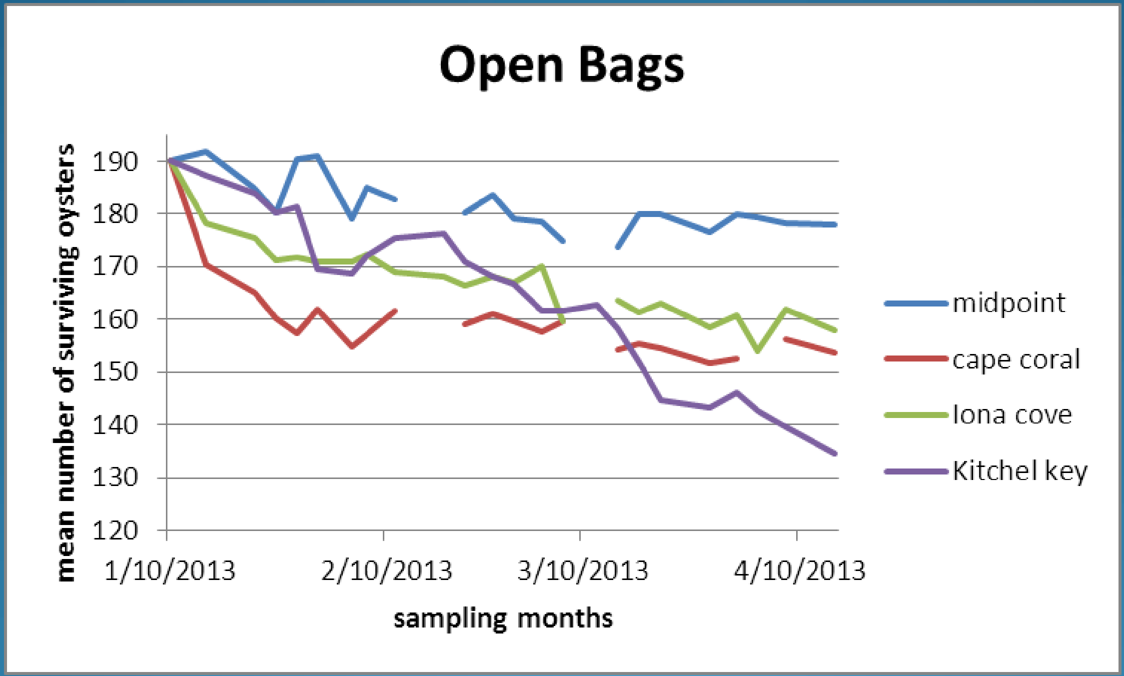
Predation Pressure



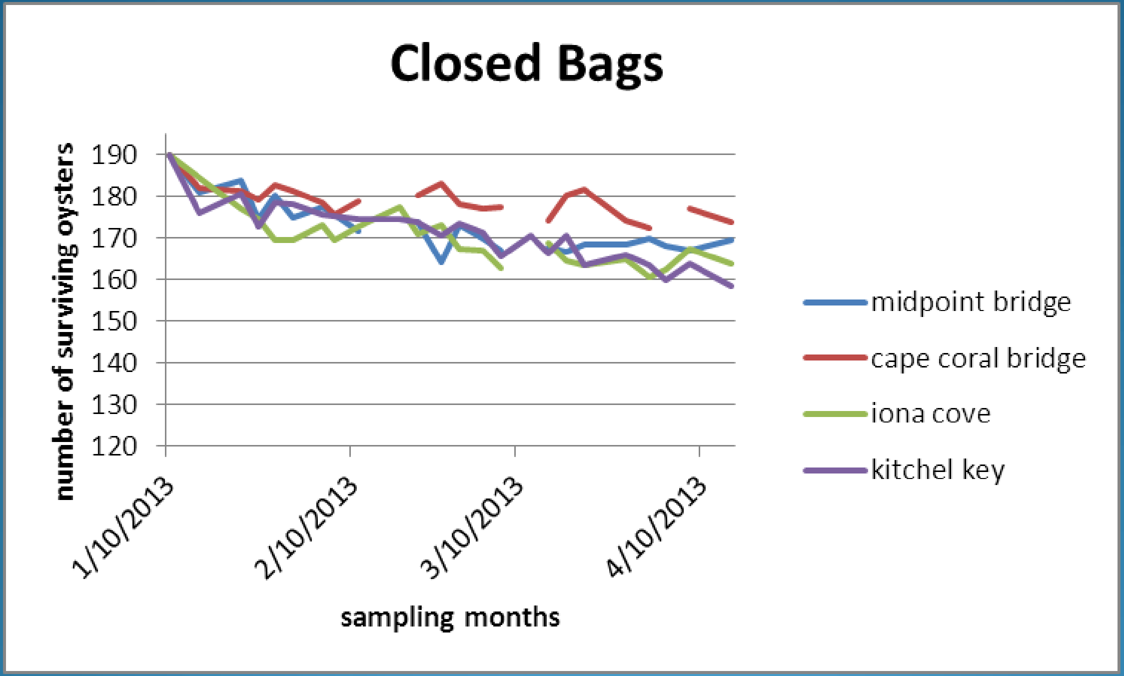
Dry season salinities



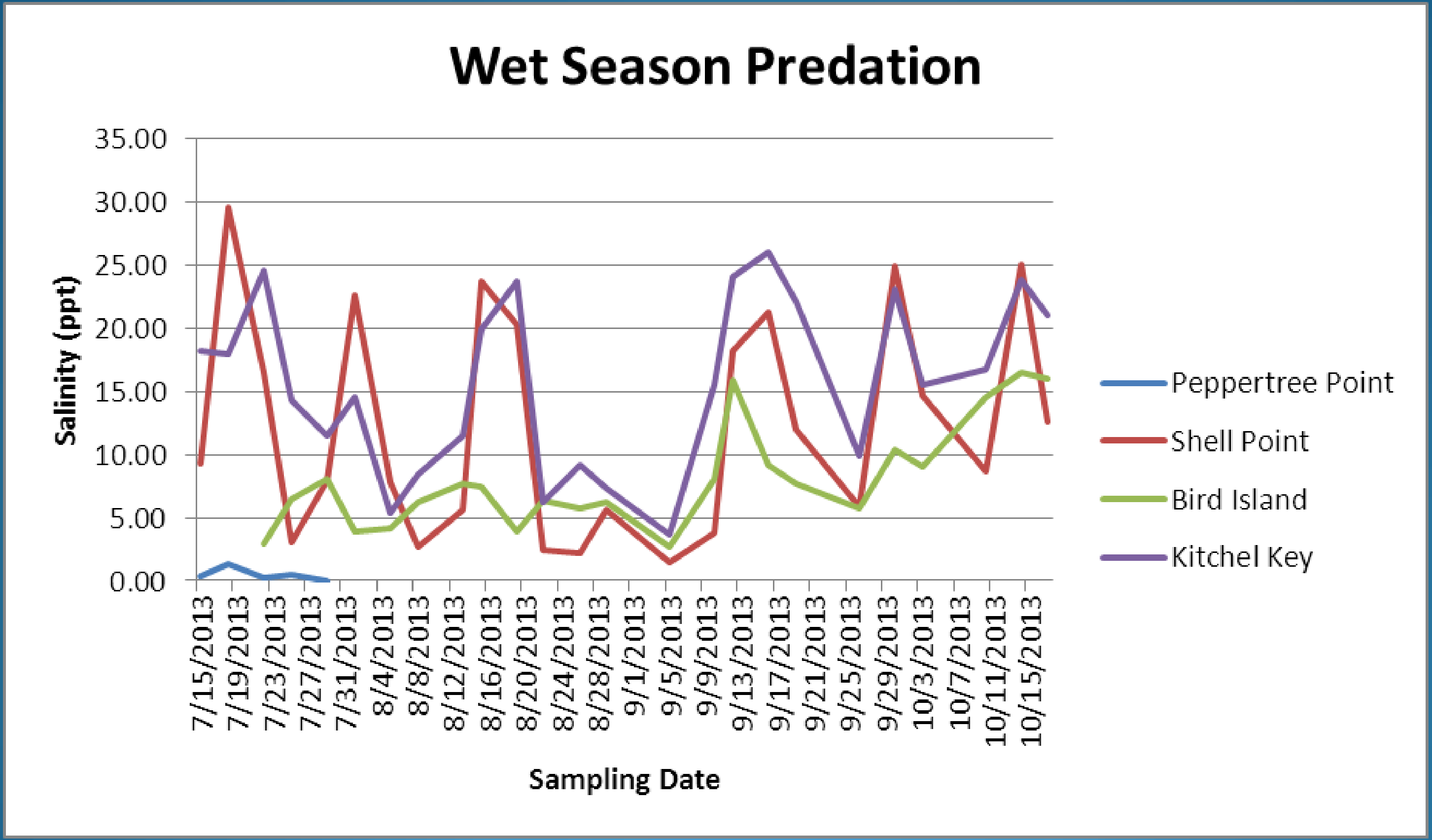
Dry Season Survival



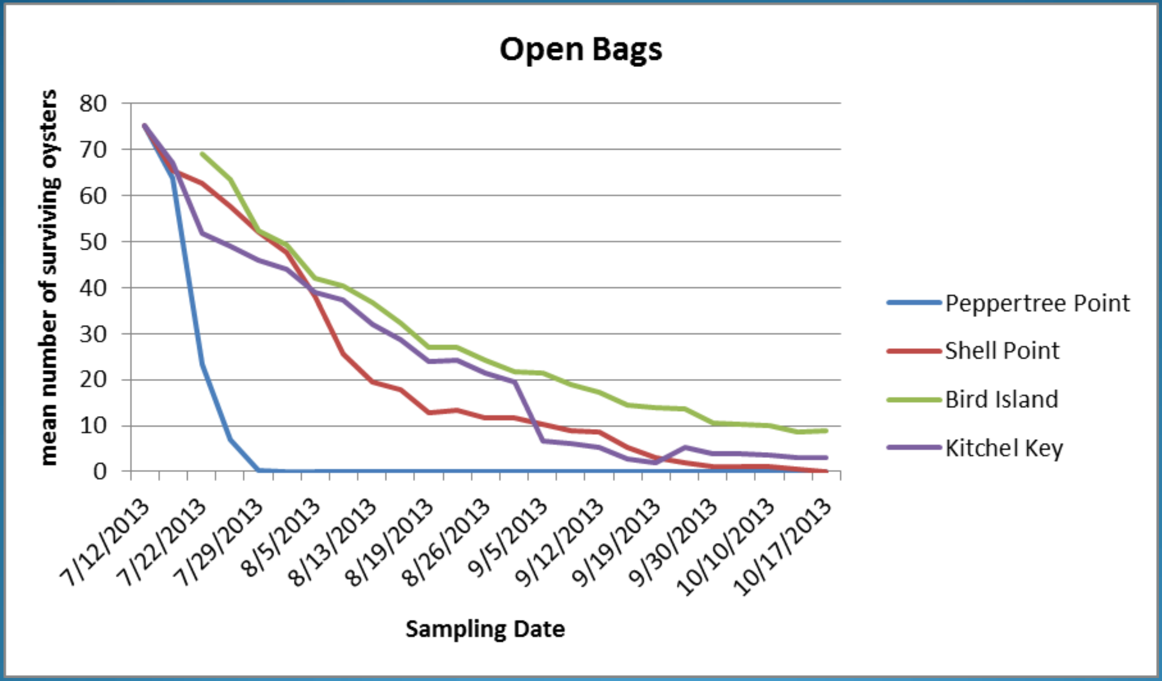
Dry Season Survival



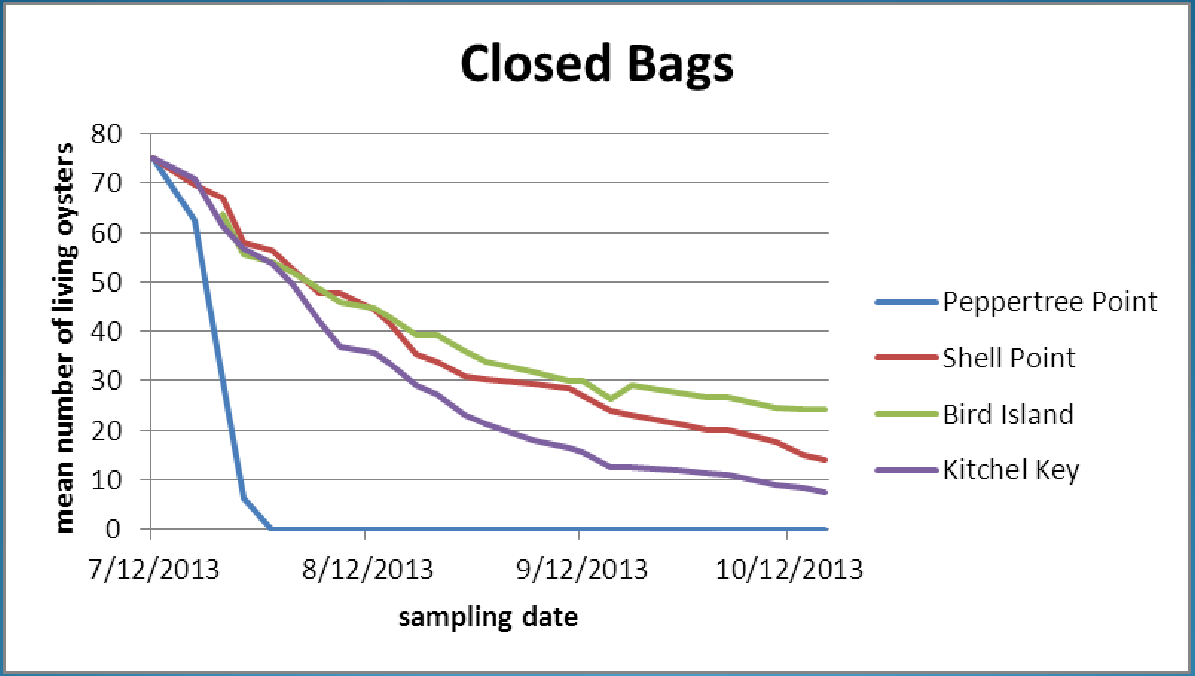
Wet Season Salinities



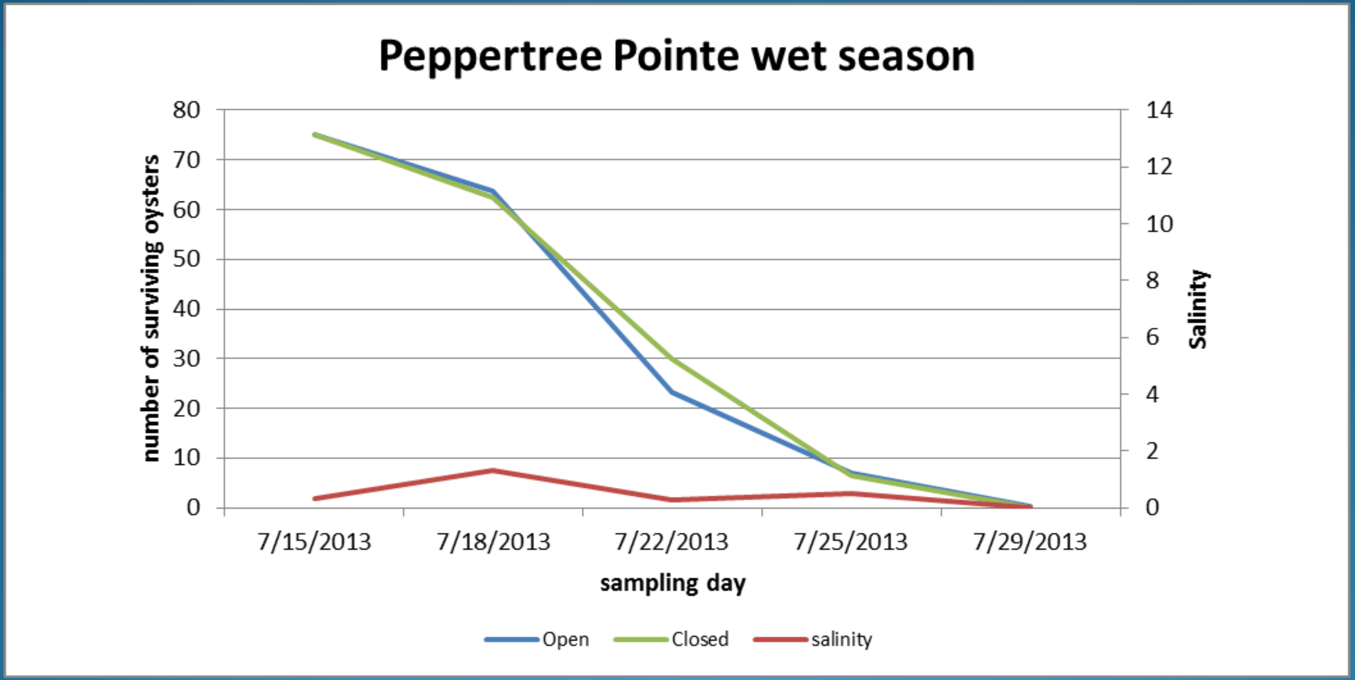
Wet Season Survival



Wet Season Survival



Peppertree Pointe Wet Season



Effect of salinity on growth and survival

Early Life Stages – Gametes, Embryos, Larvae and Spat

Oyster life cycle

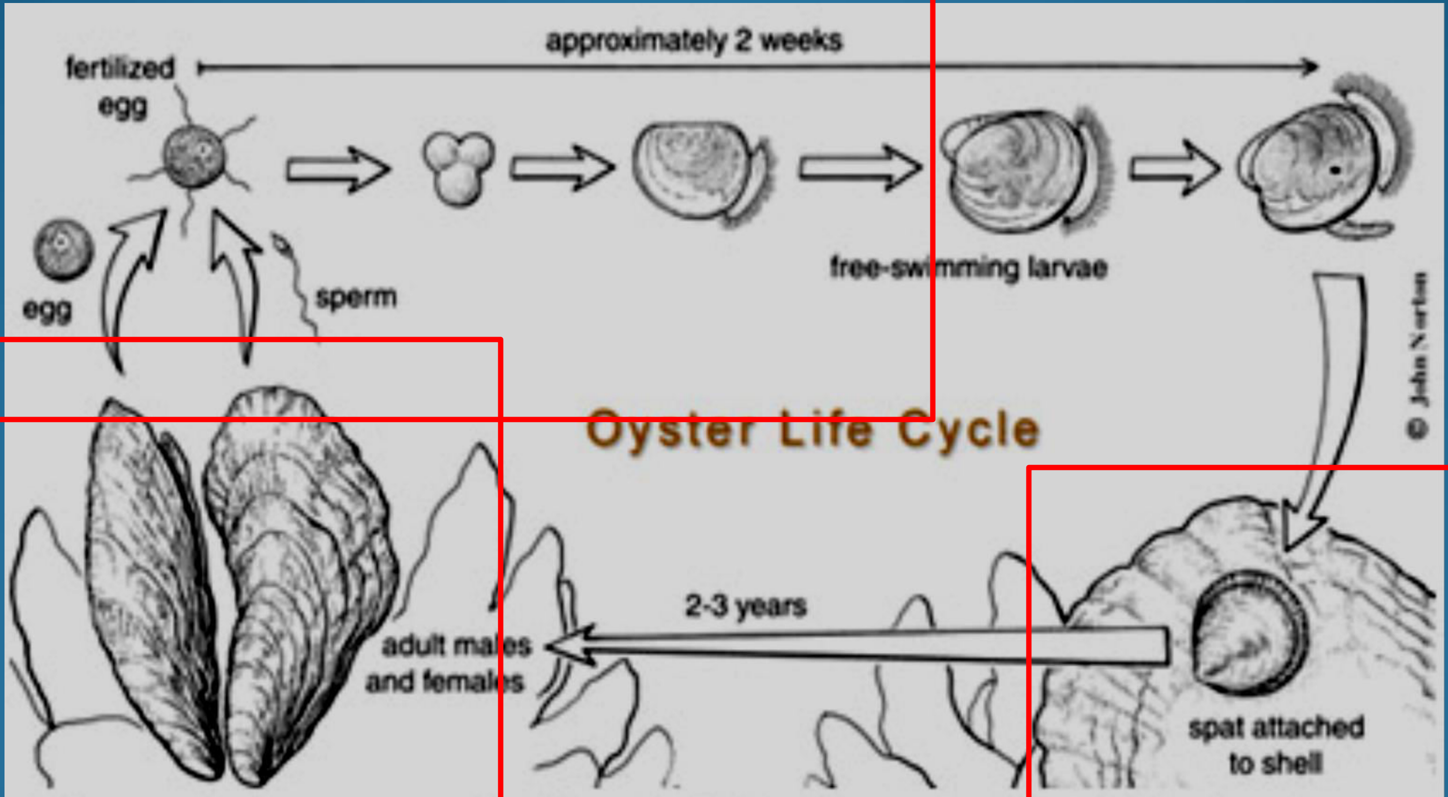


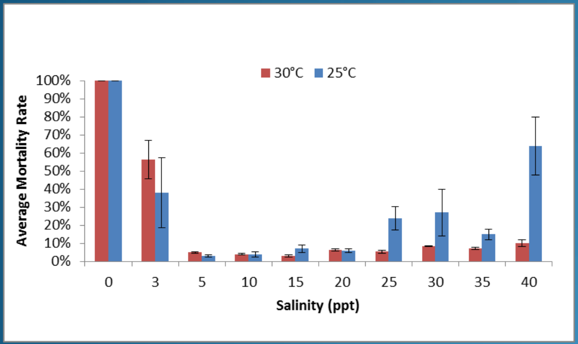
Figure 1. An example of a shellfish life cycle (from Maryland Sea Grant).

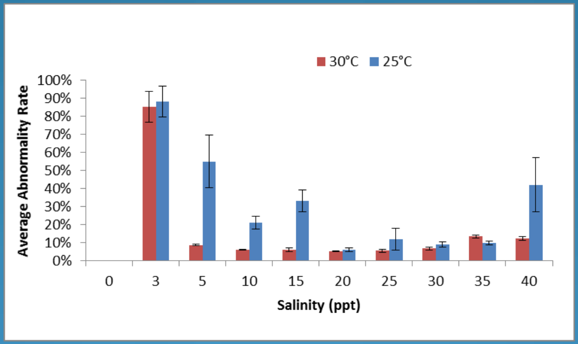
Experimental setup

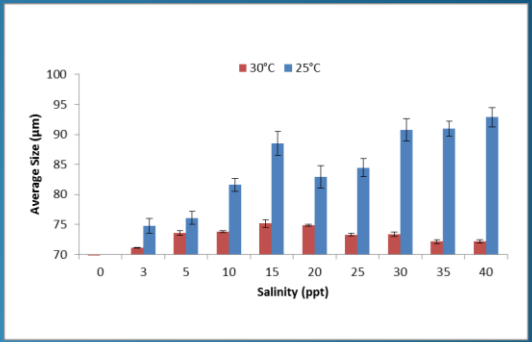
Exposure Stage		Ending Stage	End Points
Gametes (25^0 and 30^0 C)	→	Larvae	Abnormality, Mortality, Size
Embryos (25^0 and 30^0 C)	→	Larvae	Abnormality, Mortality, Size
Larvae (30^0 C)	→	Larvae	Abnormality, Mortality, Size
Spat (25^0 C)	→	Spat	Survival

Larvae exposures

Measurements of larvae after 4 days of exposure







High mortality at low salinities (0 and 3 ppt)

Survival of larvae to lower salinities is greater than that of gametes and embryos

Higher rates of abnormal larvae ≤ 3 ppt at both temperatures

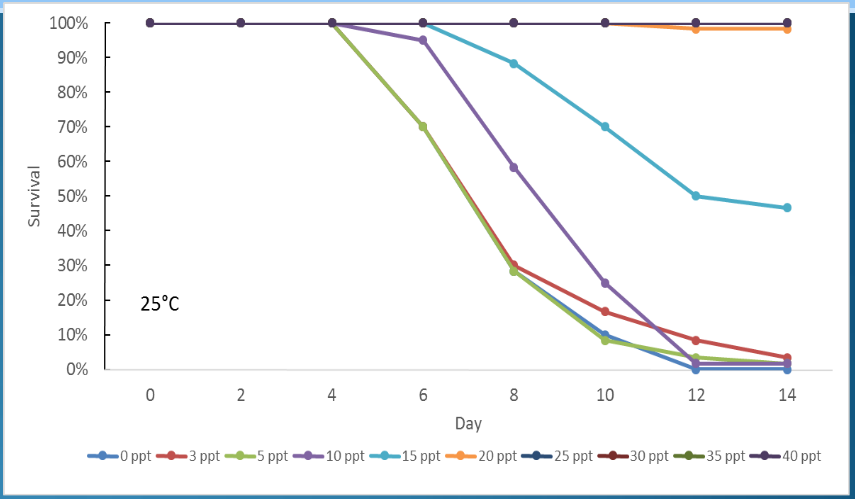
Higher growth rates at moderate to high salinities (15 – 40 ppt)

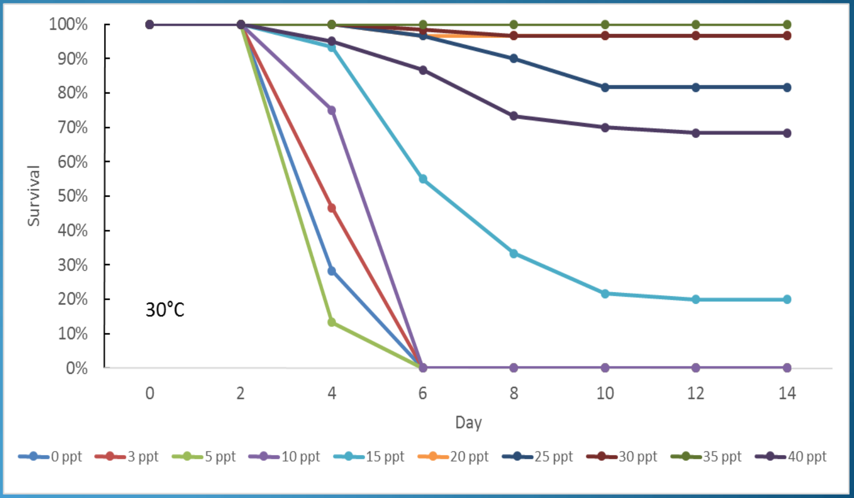
Spat exposures

- Oyster spat were exposed to both acute and gradual salinity decreases at two different temperatures (25 and 30°C)
  - 25°C – control temperature
  - 30°C – summer temperature
- Acute decrease – simulate large and continuous fresh water release
- Gradual decrease – simulate smaller pulses of fresh water release
- Statistical Analysis: Two-way ANOVA with a post hoc Tukey HSD

Acute decrease

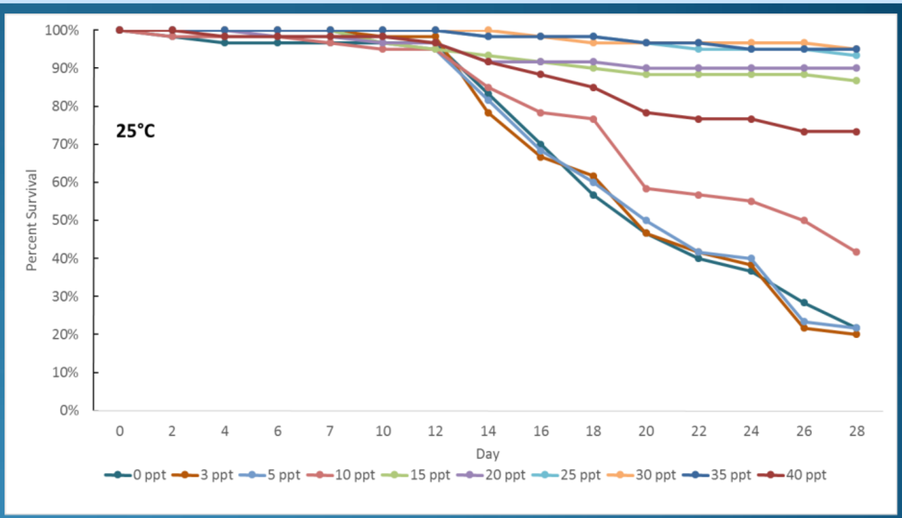
- Faster mortality at higher temperatures (30°C)
- >96% mortality at salinities ≤ 10 ppt at both temperatures
  - 25°C: day 12 - 14
  - 30°C: day 6 (100% mortality)
- Combination of temperature + salinity stress = increased mortality rates

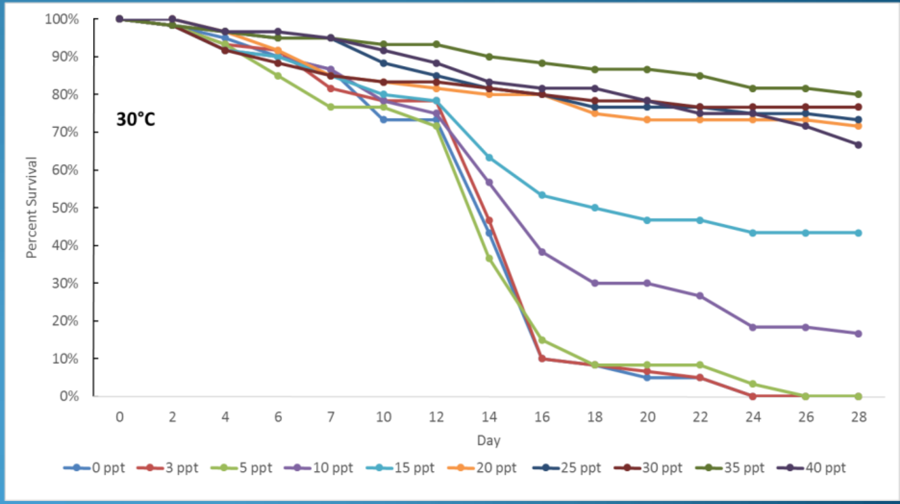




Gradual decrease

- Faster mortality at higher temperatures (30°C)
- Both temperatures had low survival at ≤ 10 ppt (< 50%)
- At 15 ppt:
    - 87% survival at 25°C
    - 43% survival at 30°C
- 15 ppt is typically suitable for oysters





Larval exposure

- Overall increased mortality was observed at all salinities during high temperature exposures (30°C)

- Mortality rate also increased when the exposure to low salinity was acute versus gradual

Survival of spat at 15 ppt during exposures

Temperature	Acute	Gradual
25°C	53%	87%
30°C	20%	43%

Adult exposure

- Gradual salinity decrease from 25 ppt (control) down to 3 or 7 ppt.
- For each salinity treatment one set of tanks remained at the set low salinity as a low salinity control to simulate continuous fresh water releases
- A second set of tanks at each low salinity was raised to 10 and 14 ppt respectively to simulation pulses of fresh water flow
- Statistical analysis: One-way ANOVA with post hoc Tukeys HSD

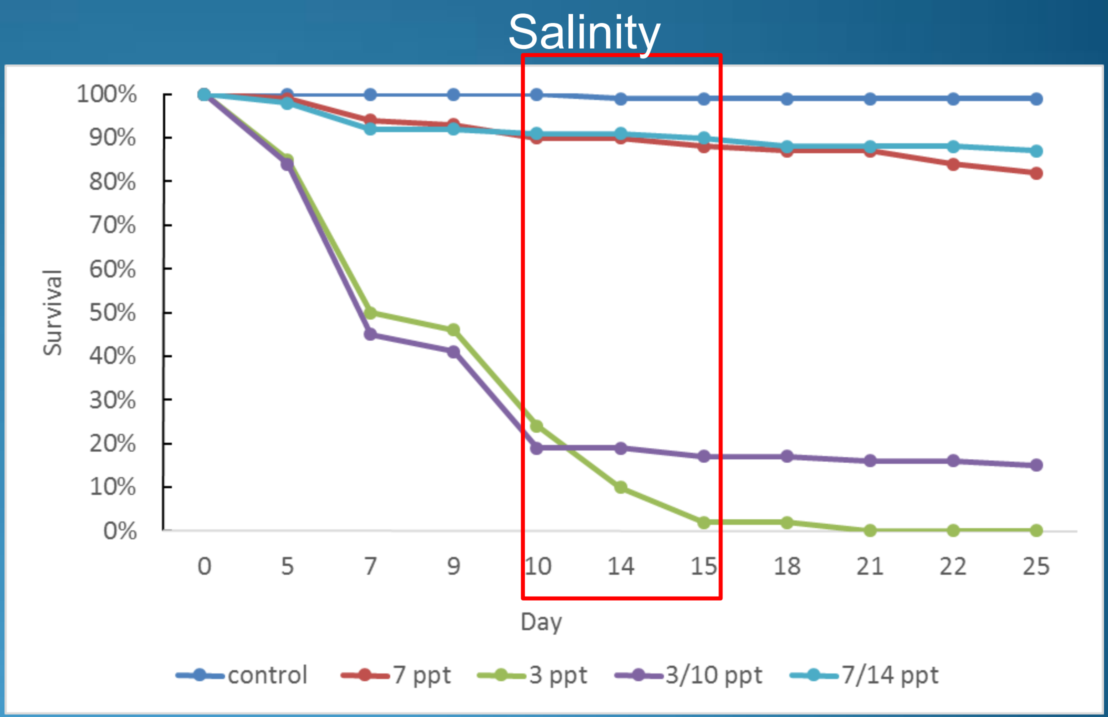
Adult exposure

Control (25 ppt) had significantly higher survival than all other treatments

Treatments of continuous exposure to 7 ppt and pulsing of 7 to 14 ppt were not significantly different from each other

Exposure to 3 ppt, both continuous and pulse, were significantly lower than all other treatments

Further, continuous exposure to 3 ppt resulted in significantly lower survival with 100% mortality by day 21



Conclusions

- Prolonged and high volume fresh water releases could result in flushing out the larval supply from the Caloosahatchee estuary
- Further, low salinity exposure during the summer months when temperature is high (ie: 30°C exposure) may result in increased mortality in early life stages (gametes, embryos and larvae)
- Mortality on adults during prolonged freshwater releases (no pulsing) will further reduce densities
- Consecutive years of fresh water releases could result in drastic declines in brood stock populations

Conclusions

Cascading effects of a reduction in oyster reefs

- Oysters provided a refuge for many commercially and economically important species of fish and crab
- Oysters filter the water column
  - Reduce phytoplankton blooms
  - Increase light attenuation (to benefit seagrasses)
  - Aid in nutrient cycling and combatting effects of eutrophication
- Stabilization of the shoreline
  - Provide substrate for mangroves
  - Aid in increasing sedimentation

Acknowledgements

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